
Integrating Safety in Design

Gary Hagan
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Y-12 Objectives and Strategies

Strategic Objective 1

- Ensure the safety, health, and protection of workers, the public, and the environment.

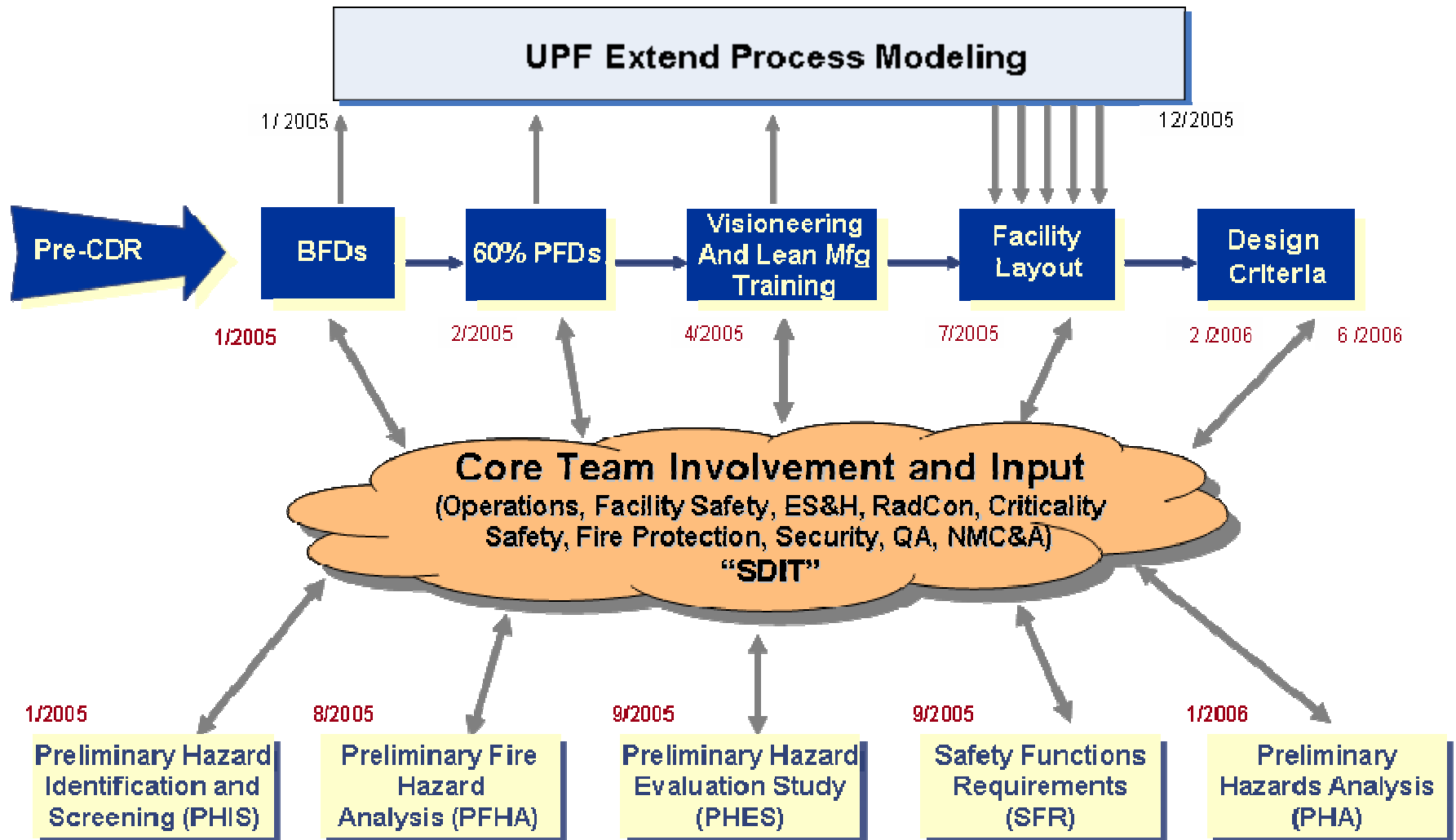
Strategies to Achieve This Objective

- Fully integrate safety into the design of new equipment and facilities.

Objectives and Strategies	
	STRATEGIC OBJECTIVE 1 ENSURE THE SAFETY, HEALTH, AND PROTECTION OF WORKERS, THE PUBLIC, AND THE ENVIRONMENT.
STRATEGIES TO ACHIEVE THIS OBJECTIVE <ul style="list-style-type: none">• Achieve a goal of Target Zero (zero occupational injuries/illnesses) by implementing a human performance-based, integrated safety improvement plan.• Achieve site Environmental Management System targets and objectives to reduce low-level waste storage areas, unneeded materials, and chemicals.• Establish an employee wellness program to improve employee behaviors and health and to enhance productivity.• Fully integrate safety into the design of new equipment and facilities.	<i>The nature of our work demands actions that far exceed those of most private or commercial enterprises. In our nuclear business, we work with hazardous, high-consequence materials in facilities that demand the highest code of operational conduct. As we work to achieve our vision, we will ensure the safety and health of every worker, the public, and the environment.</i>
KEY SUCCESS INDICATORS <ul style="list-style-type: none">• Full implementation of the integrated safety improvement plan.• Implementation of an employee wellness program.• Achievement of the best safety record among NWC sites by 2008.• Recognized excellence in environmental compliance and waste management.	

UPF Conceptual Design

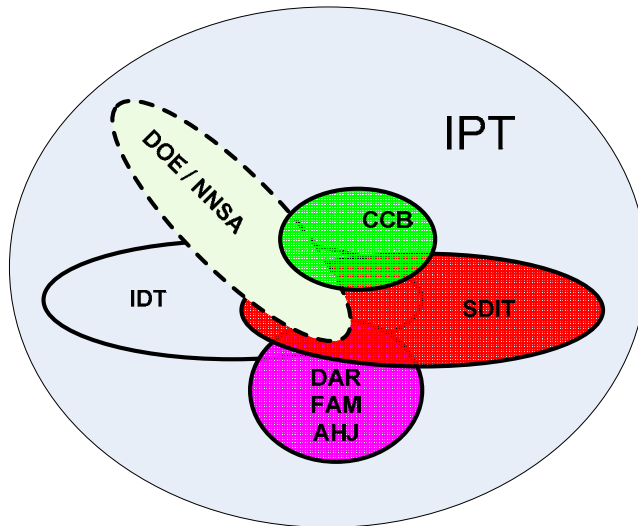
- UPF has integrated safety and security into design



Approach to Integration Planning

- Develop an Integrated Management Plan
- Identify disciplines that systematically submit design features and controls.
 - Flow sheet the process
 - Coordinate the points of technical integration
 - Synchronize hazard evaluation studies
 - Define the process for resolution and elevation through the Integrated Project Team
 - Schedule the integration points and activities

Integrated Management Plan

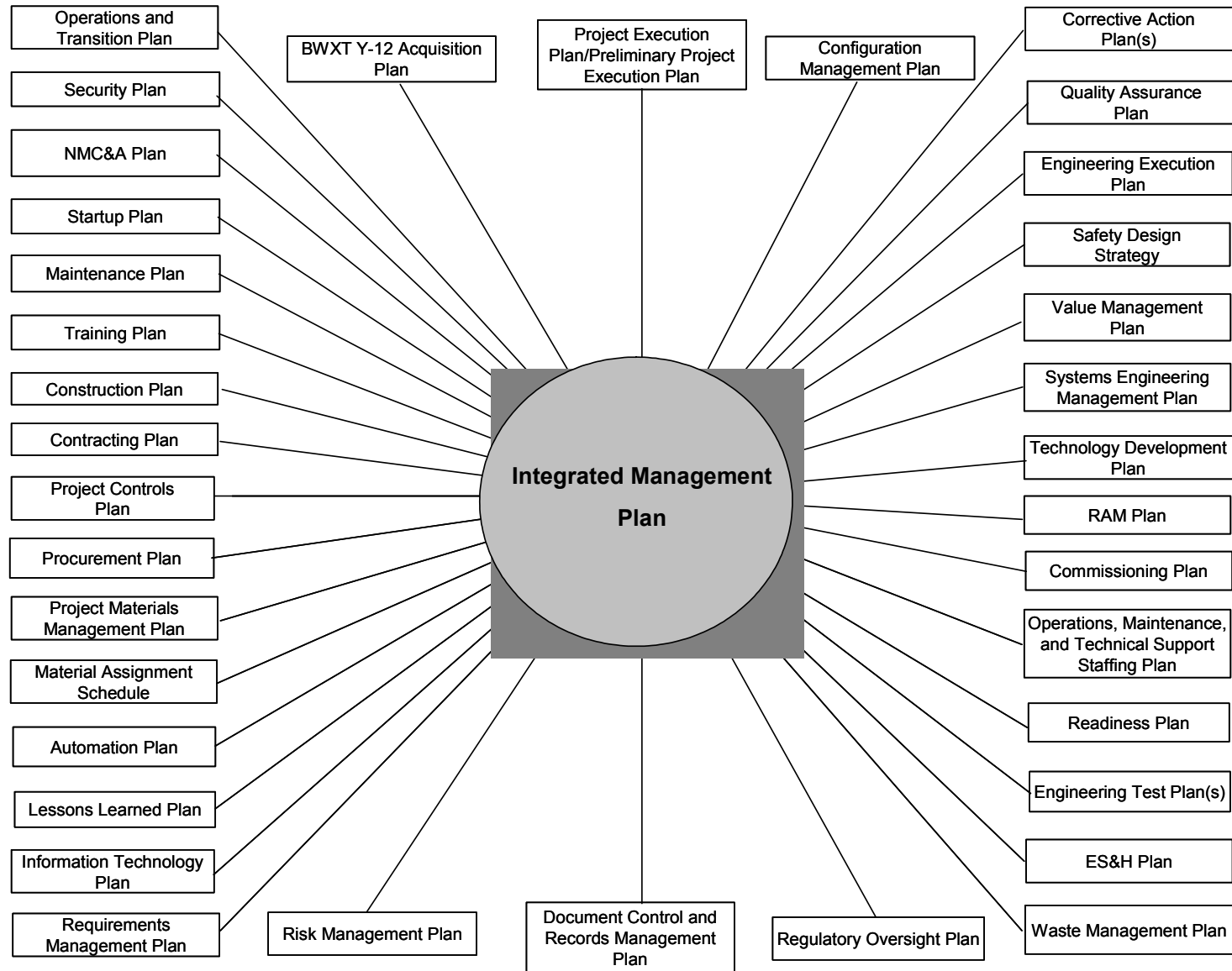


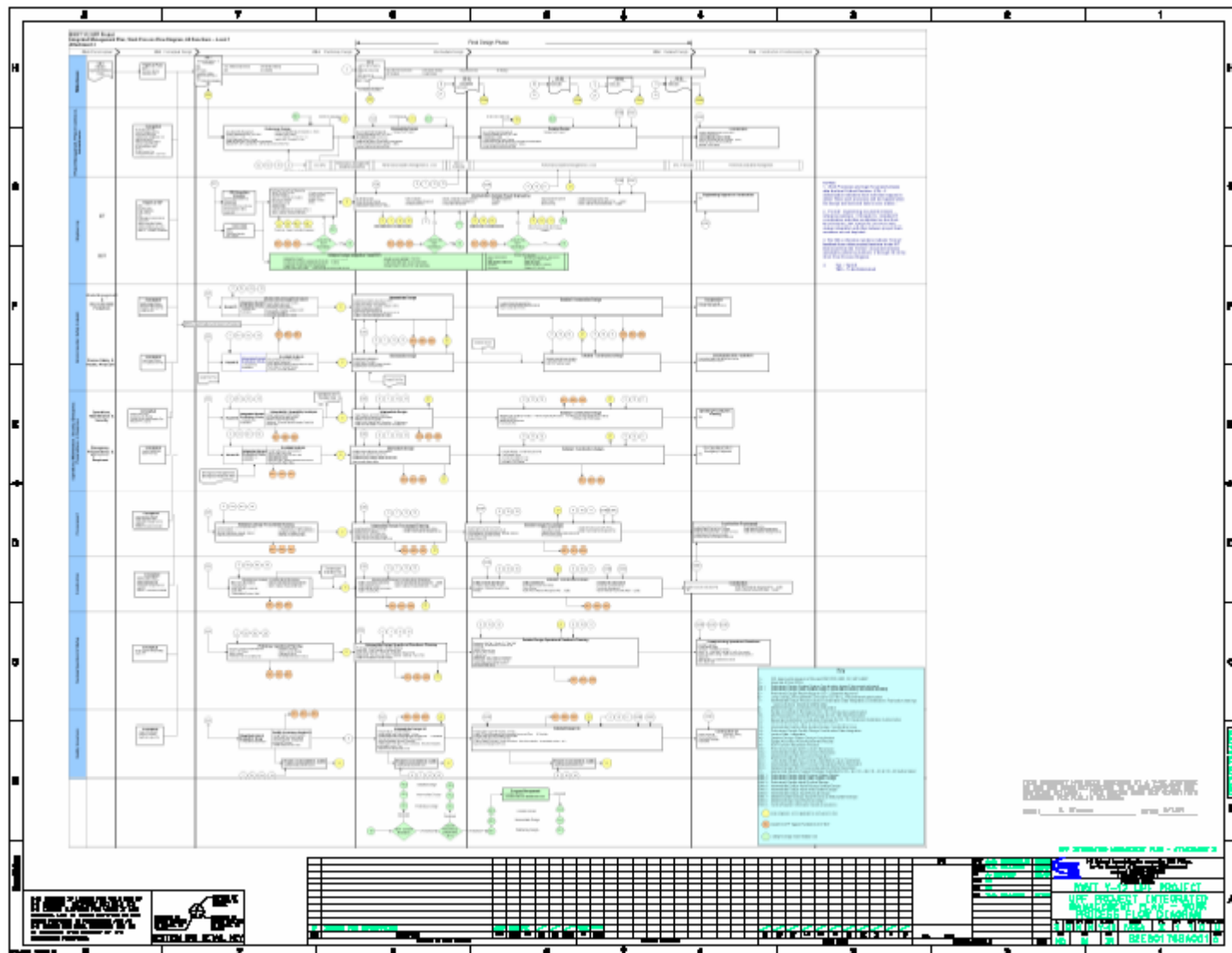
CCB – Change Control Board
 IDT – Integrated Design Team
 IPT – Integrated Project Team
 FAM – Functional Area Manager
 AHJ – Authority Having Jurisdiction
 SDIT – Safety-In-Design Integration Team
 DAR – Design Authority Representative
 DOE – Department of Energy
 NNSA – National Nuclear Security Administration

Core Team				Other Subject Matter Experts (as required)			
Organization	Supported By Project/Site	Organization	Supported By Project/Site	Organization	Supported By Project/Site	Organization	Supported By Project/Site
Safety	Site	Safety Analysis Engr.	Project	Construction Safety	Site	Maintenance	Site
Industrial Hygiene	Site	Criticality Safety	Project	Construction	Site	UPF Start-up	Site
Rad Con	Site	Fire Protection	Site & Project	Procurement	Project	Technology Development	Project
Environmental Compliance	Site	Nuclear Operations & Start-up	Site	Human Performance Improvement	Site	Technical Specialists (inc. Design Engineering)	Site & Project
Waste Operations	Site	Safeguards and Security	Project	Legal	Site	Y-12 Readiness	Site
Emergency Preparedness	Site	Operations	Site & Project	Project Controls	Project	Occupational Medicine	Site
Emergency Response	Site	Environmental, Safety & Health	Project				
Quality Assurance	Project						

Oversight by YSO (Project and Site)

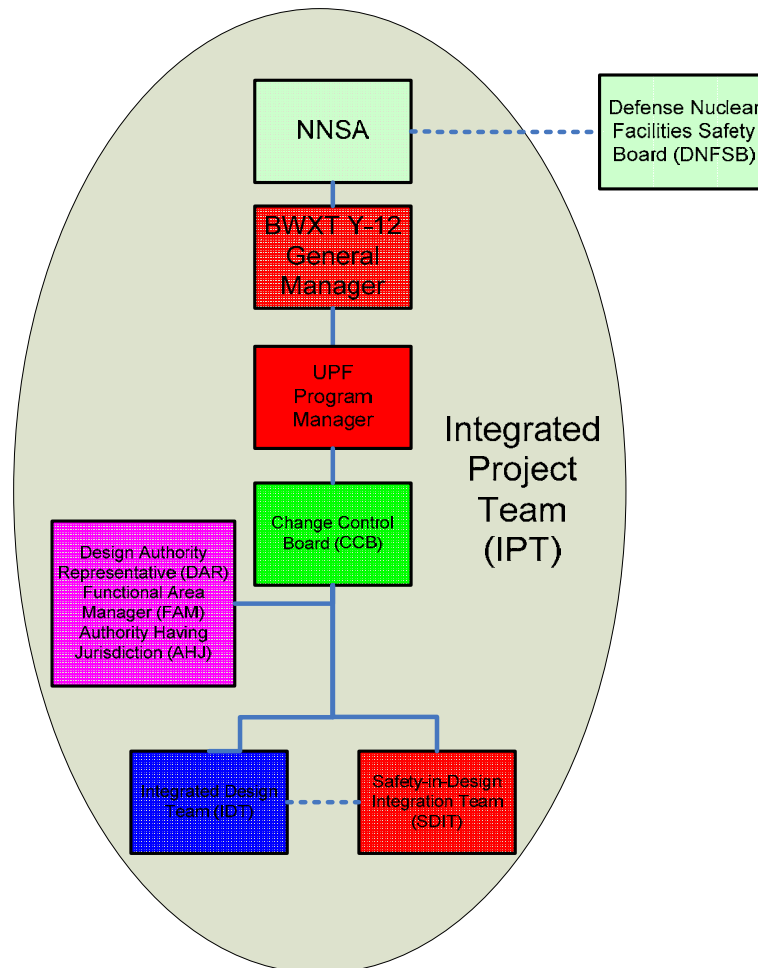
Integrated Management Plan





Safety-in-Design Integration Team

- SDIT Reporting Relationships On UPF



Safety-in-Design Integration Team

- SDIT Objectives:

- Ensure collaboration and consensus between design and safety support functions has occurred.
- Capture, manage, and work with designers to develop solutions to concerns, cross-discipline professional differences of opinion, and requirement conflicts that arise during the design process.
- Achieve consensus on a low composite design solution that meets requirements and criteria before recommending that design proceed related to that concern.
- Elevate any requirement conflicts, minority reports, and concerns that are unable to be resolved in a timely manner the Design Authority, affected Functional Area Managers, Authorities having Jurisdiction for resolution.
- Trend all design solutions that result in a change to the baseline.
- Ensure design integration tools are used consistently (e.g. 3D/4D computer-aided design (CAD), document review software, requirements management software, and other collaborative software).

SDIT Meetings/Actions

- Actions to-date:
 - Integrated Management Plan Input
 - Charter and Approaches Input
 - Work Flow Diagram Input
 - Monthly SDIT Project Status Meetings
 - Issue Specific SDIT Meetings
 - Design Criteria
 - Machining Containment
 - HVAC Confinement
 - SS, SDC-2 Fire Alarms
 - Others
 - Daily Collaboration Within Co-located Project Team

Integrated Hazard Evaluation Studies

- Keeping objectives aligned with information availability
 - Be prepared to respond to “clairvoyance expectation”
- Verify pre-requisites available
- Critical Role of Leaders and Scribes
- Group size and composition
 - Availability of the right team members
- Keeping activities synchronized

Unexpected Benefits

- Excellent Forum To Resolve Non-safety Technical And Programmatic Issues
- Information Exchange Within Integrated Design Team
- Training Opportunities
- Benefits to Support Facilities

Top Challenges

- Requirements conflicts
 - Project advocates and scrutineers want to sub-optimize around parochial topic.
 - Selecting the lowest composite risk design solution must remain the project teams objective.
- Requirement complexity
 - Expect to deal with 2000 to 4000 requirements with major projects

Security and Emergency Response



Top Challenges

- Advancing the “how we intend to operate the equipment” in concert with hardware development
- Chemical Safety
- Design for Construction Safety
 - not just constructability
- Sustainable design
- Environmental permitting – NEPA Non-attainment
- Human Performance Improvement

HPI-Specific Ergonomic Tests

- **RULA** (Rapid Upper Limb Assessment) : to test postures, forces, and activities that have been shown to contribute to Repetitive Strain Injuries (RSIs)
- **Snook and Ciriello** : to test frequencies of repetitive motion
- **Fit** : to test if the target population fits the workspace
- **Reach** : to test if the target population can reach controls and displays
- **Vision** : to test if the target population can view adequately controls and displays and to ensure that their view is not obstructed

RULA – Rapid Upper Limb Assessment

- **Evaluates individuals exposures to postures, forces, and muscle activities that have been shown to contribute to Repetitive Strain Injuries.**
- **Developed by Drs. Lynn McAtamney and E. Nigel Corlett and first described in 1993.**
- **This ergonomic evaluation approach results in a risk score between one and seven, where higher scores signify greater levels of apparent risk.**

Typical RULA Worksheet

RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position



Step 1a: Adjust...

If shoulder is raised: +1;
If upper arm is abducted: +1;
If arm is supported or person is leaning: -1

Final Upper Arm Score =

Step 2: Locate Lower Arm Position

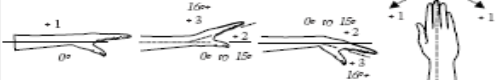


Step 2a: Adjust...

If arm is working across midline of the body: -1;
If arm out to side of body: +1

Final Lower Arm Score =

Step 3: Locate Wrist Position



Step 3a: Adjust...

If wrist is bent from the midline: +1

Final Wrist Score =

Step 4: Wrist Twist

If wrist is twisted mainly in mid-range =1;
If twist at or near end of twisting range = 2

Wrist Twist Score =

Step 5: Look-up Posture Score in Table A

Use values from steps 1, 2, 3 & 4 to locate Posture Score in table A

Posture Score A =

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or;
If action repeatedly occurs 4 times per minute or more: +1

Muscle Use Score =

Step 7: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

Step 8: Find Row in Table C

The completed score from the Arm/wrist analysis is used to find the row on Table C

Final Wrist & Arm Score =

SCORES

Table A

Upper Arm	Lower Arm	Wrist			
		Wrist twist	Wrist twist	Wrist twist	Wrist twist
1	1	1	2	1	2
	2	2	2	2	3
	3	3	3	3	4
2	1	2	3	3	4
	2	3	3	3	4
	3	3	4	4	5
3	1	3	4	4	5
	2	4	4	4	5
	3	4	4	5	6
4	1	5	5	6	6
	2	5	6	6	7
	3	6	6	7	7
5	1	7	7	7	8
	2	8	8	8	9
	3	9	9	9	9
6	1	7	7	7	8
	2	8	8	8	9
	3	9	9	9	9

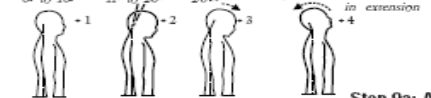
Table C

	1	2	3	4	5	6	7
1	1	2	3	4	5	6	7
2	2	3	4	5	6	7	8
3	3	4	5	6	7	8	9
4	4	5	6	7	8	9	9
5	5	6	7	8	9	9	9
6	6	7	8	9	9	9	9
7	7	8	9	9	9	9	9

Final Score =

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position



Step 9a: Adjust...

If neck is twisted: +1; If neck is side-bending: +1

Final Neck Score =

Step 10: Locate Trunk Position



Step 10a: Adjust...

If trunk is twisted: +1; If trunk is side-bending: +1

Final Trunk Score =

Step 11: Legs

If legs & feet supported and balanced: +1;
If not: +2

Final Leg Score =

Trunk Posture Score

	1	2	3	4	5	6
Neck	1	2	1	2	1	2
1	1	3	2	3	4	5
2	2	3	2	3	4	5
3	3	3	3	4	5	6
4	4	5	5	6	7	7
5	5	6	6	7	7	8
6	6	7	7	7	8	8
7	7	8	8	8	8	8

Table B

Step 12: Look-up Posture Score in Table B

Use values from steps 9, 10 & 11 to locate Posture Score in Table B

Posture B Score =

Step 13: Add Muscle Use Score

If posture mainly static or;
If action 4/minute or more: +1

Muscle Use Score =

Step 14: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

Step 15: Find Column in Table C

The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Final Neck, Trunk & Leg Score =

Subject: _____
Company: _____

Department: _____

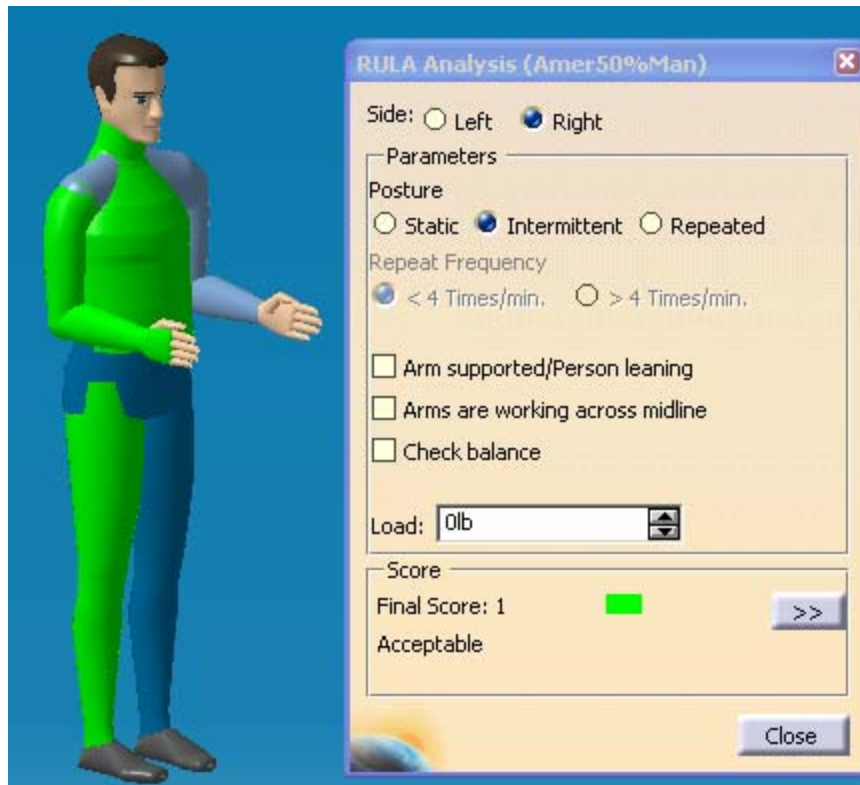
Date: ____/____/____
Scorer: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

© Professor Alan Hedge, Cornell University, Feb. 2001

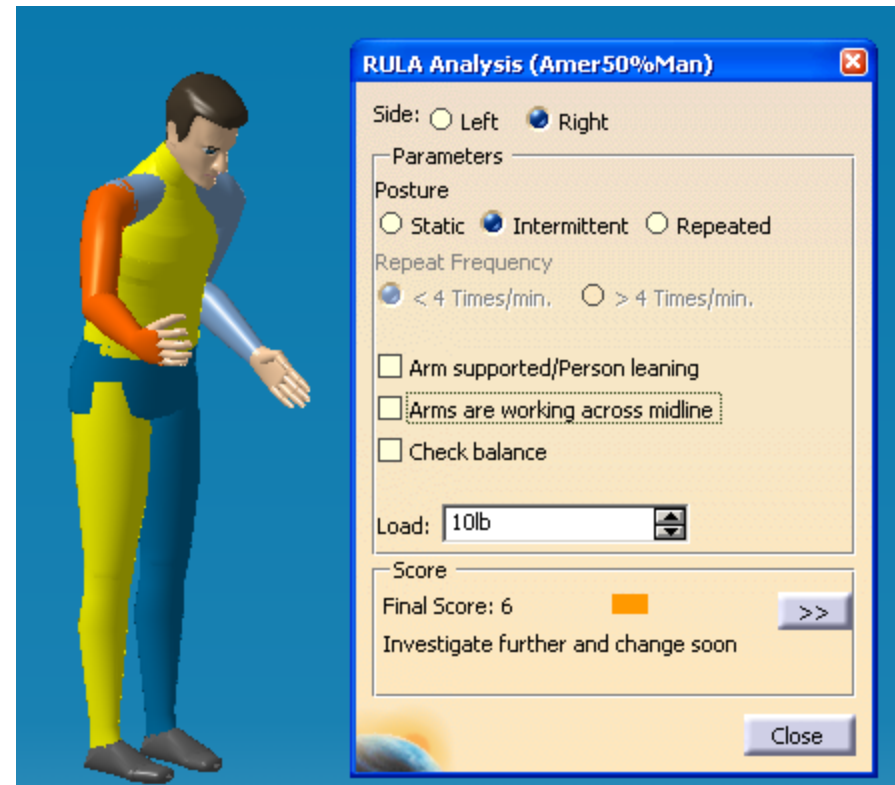
RULA – Rapid Upper Limb Assessment

FINAL SCORE: 1-2 = Acceptable; 3-4 = investigate further; 5-6 = change soon; 7 = change immediately



Final Score = 1:

- green
- indicates the posture is acceptable



Final Score = 6:

- orange
- indicates that investigation and changes are required soon

Simulation Analysis for Human Safety

- **Software uses NIOSH 81 and 91 standard equations.**
- **Provides quick method to check 5%-95% population for exposure to likely risk of upper limb disorders.**
- **Allow assessment of repetitive work.**
- **Allows re-assessing any changes in manufacturing design to improve human well-being and process productivity.**

Manual Materials Handling Tables

Female - Lifting Task Ending Below Knuckle Height (<28")

Liberty Mutual Manual Materials Handling Guidelines

* Indicates Required Entry

* Object Weight (Pounds):

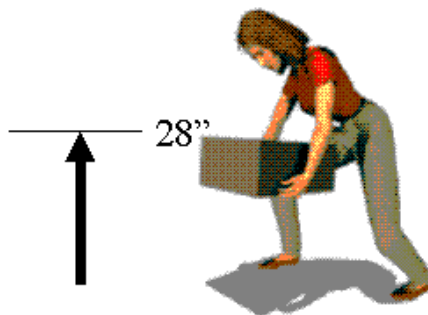
* Hand Distance:

* Lifting Distance:

* Frequency One Lift Every:

[Calculate](#)

Population Percentage: **80%**



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The illustrations, instructions and principles contained in the material are best of our knowledge, current at the time of publication. No attempt has been made to conform with codes, standards, or regulations. Please refer to the appropriate code, standard, or regulation-making authority for interpretation or clarification.

TABLE 1 F - FEMALE POPULATION PERCENTAGES FOR LIFTING TASKS ENDING BELOW KNUCKLE HEIGHT (<28")

HAND DISTANCE				7 INCHES					10 INCHES					15 INCHES		
FREQUENCY ONE LIFT EVERY				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m
OBJECT WEIGHT (POUNDS)	65	LIFTING DISTANCE (INCHES)	28	-	-	-	-	13	-	-	-	-	-	-	-	-
			20	-	-	-	-	29	-	-	-	-	14	-	-	-
			10	-	-	-	-	34	-	-	-	-	20	-	-	-
	62		28	-	-	-	-	17	-	-	-	-	-	-	-	-
			20	-	-	-	-	35	-	-	-	-	19	-	-	-
			10	-	-	-	-	40	-	-	-	-	26	-	-	-
	59		28	-	-	-	-	22	-	-	-	-	-	-	-	-
			20	-	-	-	-	41	-	-	-	-	25	-	-	-
			10	-	-	-	-	46	-	-	-	-	32	-	-	-
	56		28	-	-	-	-	29	-	-	-	-	14	-	-	-
			20	-	-	-	-	48	-	-	-	-	31	-	-	-
			10	-	-	-	-	53	-	-	-	-	38	-	-	-
	53		28	-	-	-	-	35	-	-	-	-	20	-	-	-
			20	-	-	-	-	54	-	-	-	-	38	-	-	-
			10	-	-	-	12	59	-	-	-	-	45	-	-	-
	50		28	-	-	-	-	43	-	-	-	-	26	-	-	-
			20	-	-	-	13	61	-	-	-	-	45	-	-	-
			10	-	-	-	17	65	-	-	-	-	53	-	-	-
	47		28	-	-	-	-	51	-	-	-	-	34	-	-	-
			20	-	-	-	19	67	-	-	-	-	53	-	-	-
			10	-	-	14	24	71	-	-	-	11	60	-	-	-
	44		28	-	-	-	11	58	-	-	-	-	42	-	-	-
			20	-	-	16	27	73	-	-	-	13	60	-	-	-
			10	14	16	20	32	76	-	-	-	17	67	-	-	-
41	28	-	-	-	18	66	-	-	-	-	51	-	-	-		
	20	-	14	24	36	78	-	-	11	20	68	-	-	-		
	10	21	23	29	41	81	-	-	14	24	73	-	-	-		
38	28	-	12	16	26	73	-	-	-	13	60	-	-	-		
	20	16	22	33	46	83	-	-	18	29	74	-	-	-		
	10	30	33	38	50	85	14	16	22	34	78	-	-	-		
			28	17	19	25	37	79	-	-	11	21	68	-	-	-

Snook and Ciriello



Initial Posture



Final Posture

Lift-Lower Analysis (Amer75%Woman)

Posture: ☐ Initial ☒ Final

Guideline: Snook & Ciriello 1991

Specifications

1 lift every: 600s

Population sample: 75%

Report

Name: Lift-Lower1

Output File: hqs\kzb\My Documents\Lift-Lower1.txt

Score

Maximum Acceptable Weight: 30.401lbf

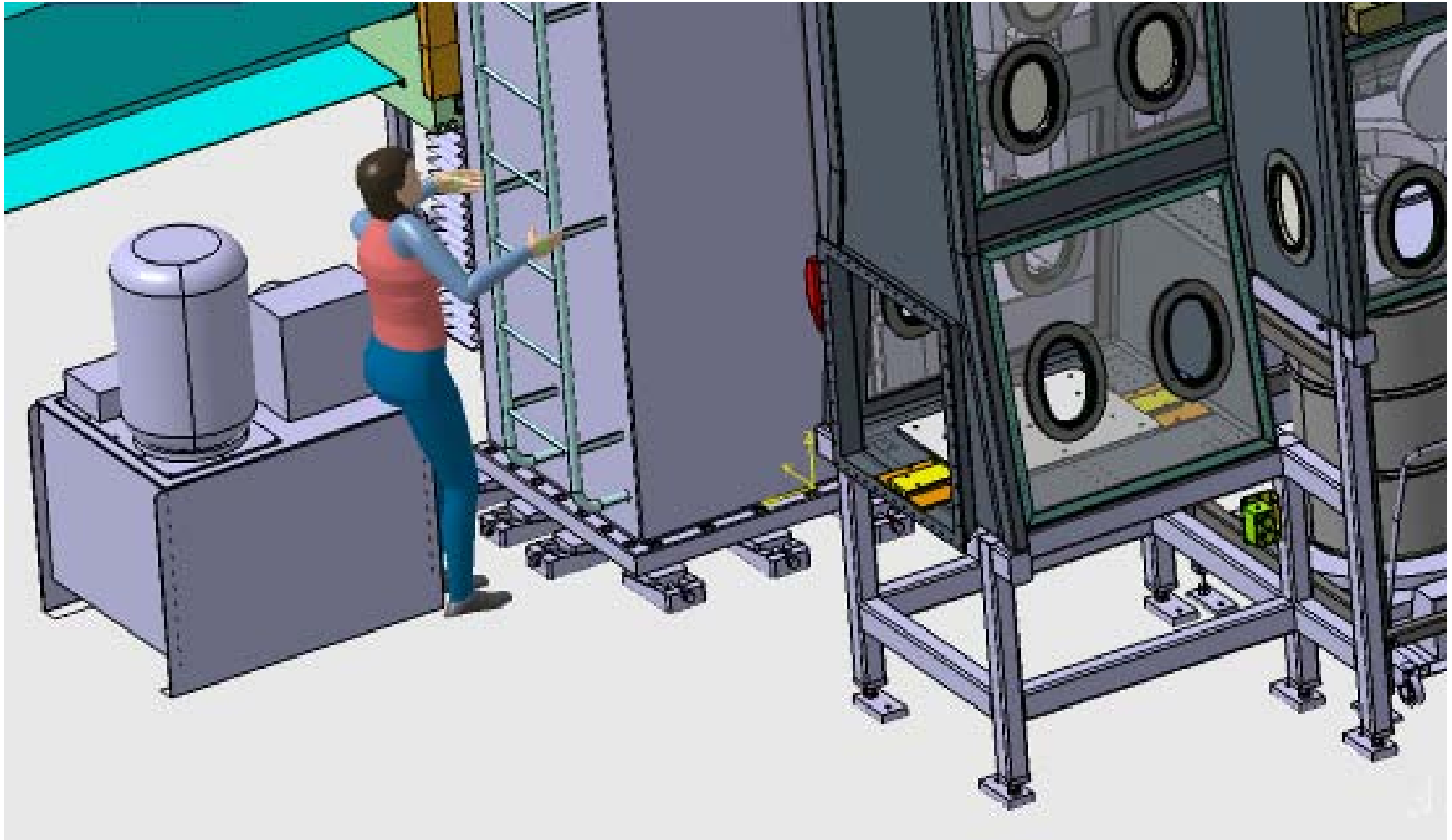
**Maximum Acceptable Weight
equals 30.40 lbf**

**A weight that the selected
population (75%) can handle
with reasonable safety.**

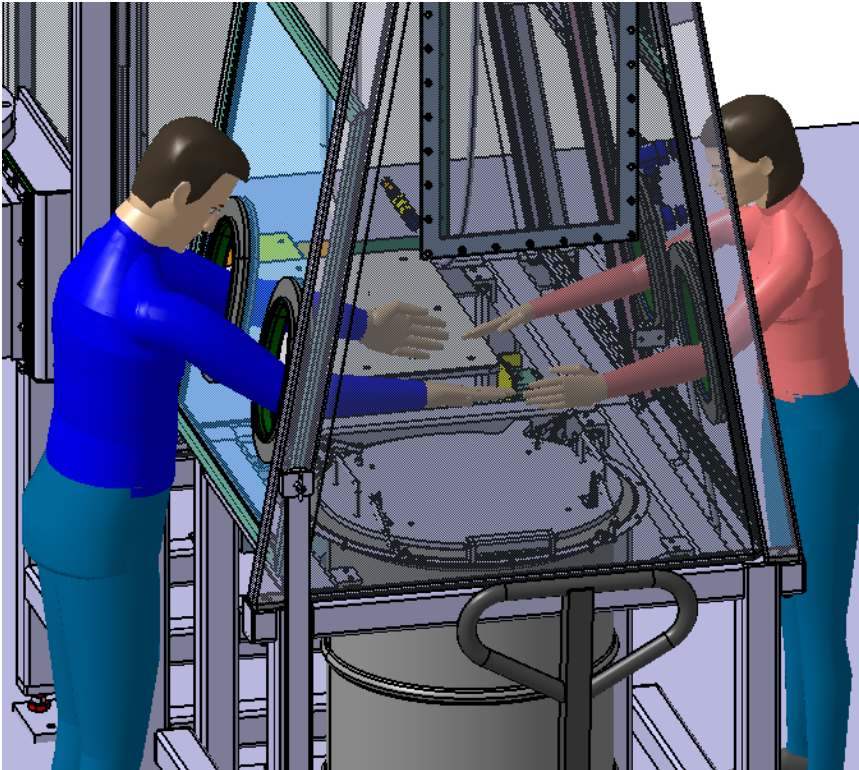
How will the equipment be operated?
In what environment will it be used?



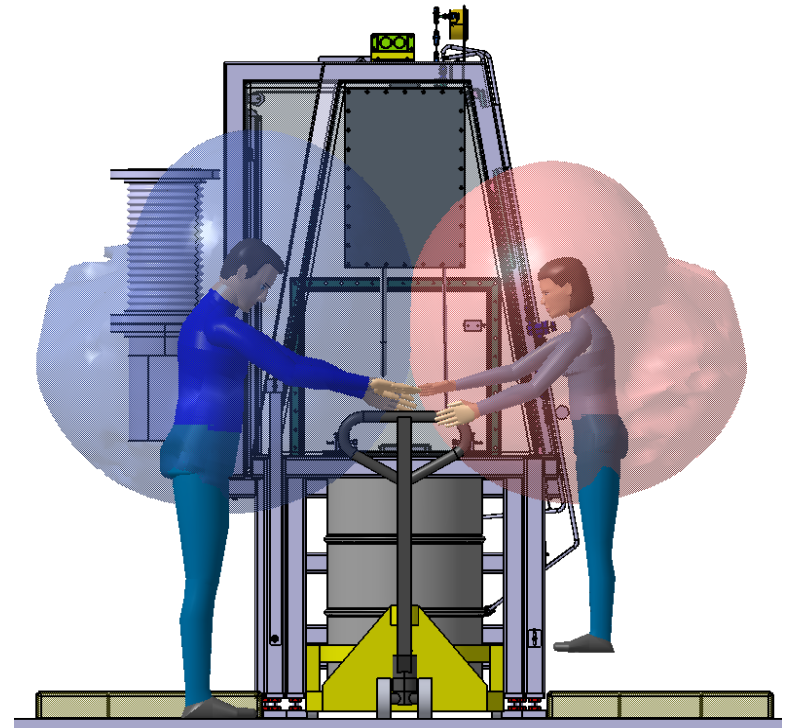
Fit Test



Reach Test



Glove box task

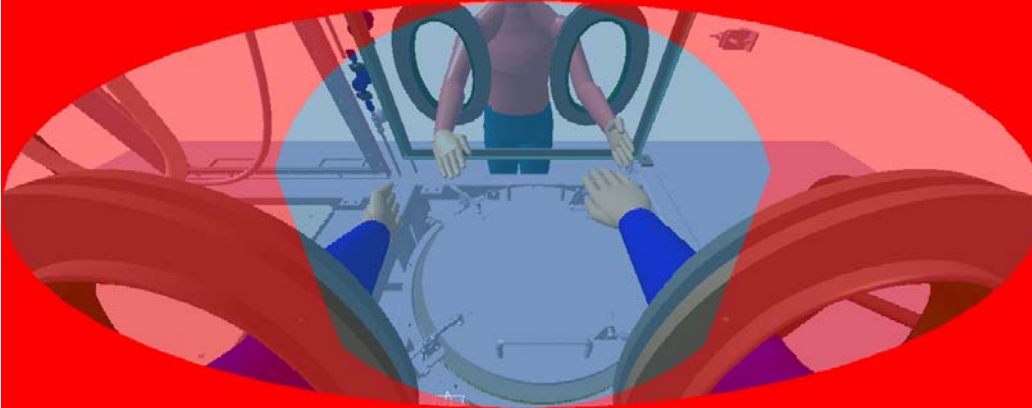


Work Envelope

Vision Test

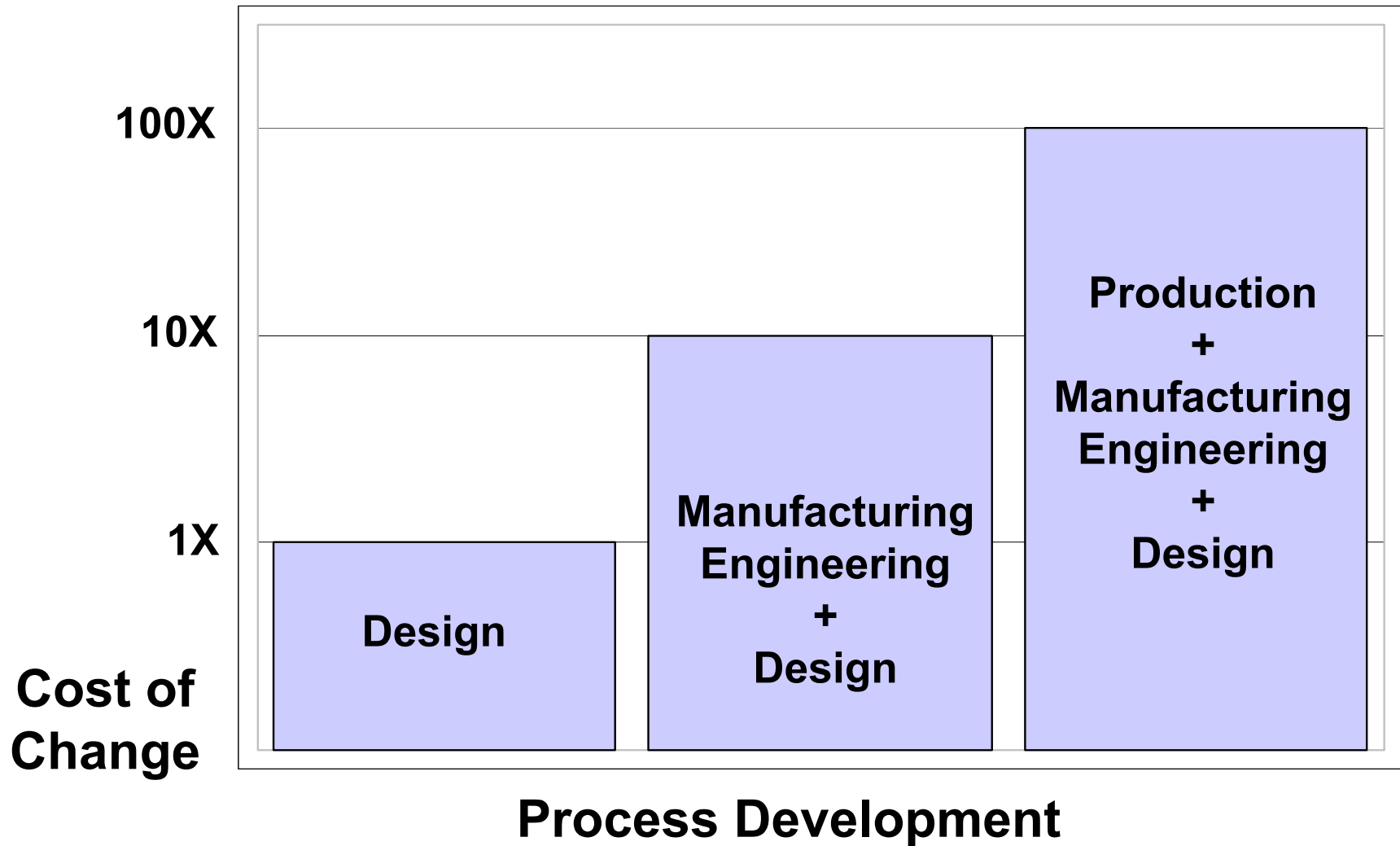
Binocular vision (Amer95Man)

American Man 95% Vision



American Woman 05% Vision

\$ Now or \$\$\$ Then



ANSYS, Inc. (2003) White Paper on the Design Innovation Process

HPI Training for Designers – Eliminate Error Likely Situation by Design

